-43-

CLAIMS

We claim:

5   1.   An apparatus for programming a non-volatile storage element,
comprising:

         a programming mode indicator providing an output indicating whether said non-
volatile storage element is in a coarse programming mode or a fine programming mode;
and

10   a switchable charge packet metering circuit in communication with said
programming mode indicator and said non-volatile storage element, said switchable
charge packet metering circuit provides a metered charge to said non-volatile storage
element in response to said programming mode indicator indicating that said non-volatile
storage element is in said fine programming mode.

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         2.   An apparatus according to claim 1, wherein:

         said switchable charge packet metering circuit comprises a source, a first switch
in communication with said source and a charge storage device, said charge storage
device is in communication with said first switch and a control line for said non-volatile

20   storage element, said first switch selectively allows said source to charge said charge
storage device.

         3.   An apparatus according to claim 2, wherein:

         said switchable charge packet metering circuit further comprises a second switch;

25   said second switch is in communication with said control line, said charge storage
device and said programming mode indicator; and

         said second switch selectively connects said charge storage device to said control

line when said programming mode indicator indicates that said non-volatile storage element is in said fine programming mode.

4. An apparatus according to claim 1, wherein said switchable charge packet metering circuit comprises:

a first source;

a first switch in communication with said first source;

a first charge storage device in communication with said first switch, said first switch selectively allows said first source to charge said first charge storage device;

a second source;

a second switch in communication with said second source;

a second charge storage device in communication with said second switch, said second switch selectively allows said second source to charge said second charge storage device; and

a third switch for selectively connecting either said first charge storage device or said second charge storage device to a control line for said non-volatile storage element based on said programming mode indicator.

5. An apparatus according to claim 1, wherein said switchable charge packet metering circuit comprises:

a variable source in communication with said programming mode indicator;

a first switch in communication with said variable source; and

a charge storage device in communication with said first switch, said first switch selectively allows said variable source to charge said first charge storage device, said charge storage device able to provide charge to said non-volatile storage element, said variable source charges said charge storage device to a first level if said programming mode indicator indicates that said non-volatile storage element is in a coarse

programming mode and charges said charge storage device to a second level if said programming mode indicator indicates that said non-volatile storage element is in a fine programming mode.

5   6.   An apparatus according to claim 1, wherein said switchable charge packet metering circuit comprises:

a source;

a first switch in communication with said source and said programming mode indicator;

10   a first charge storage device in communication with said first switch; and

a second charge storage device in communication with said first switch, said first switch selectively allows said source to charge either said first storage device or said second charge storage device based on said programming mode indicator.

15   7.   An apparatus according to claim 6, wherein:

said switchable charge packet metering circuit comprises a second switch connected between said first switch and said source so that said source is in selective communication with said first switch.

20   8.   An apparatus according to claim 1, wherein:

said switchable charge packet metering circuit comprises a source, a first switch in communication with said source, and a charge storage device;

said charge storage device is in communication with said first switch and a control line for said non-volatile storage element, said first switch selectively allows said

25   source to charge said charge storage device; and

said storage device discharges via said control line in order to program said non-volatile storage element.

9.   An apparatus according to claim 1, further comprising:

a sense circuit in communication with said non-volatile storage element, said programming mode indicator provides said output indicating whether said non-volatile storage element is in said coarse programming mode or said fine programming mode based on said sense circuit; and

a selection circuit in communication with said programming mode indicator and said sense circuit, said selection circuit provides a coarse reference signal to said sense circuit if said non-volatile storage element is in said coarse programming mode and provides a fine reference signal to said sense circuit if said non-volatile storage element is in said fine programming mode.

10.   An apparatus according to claim 9, wherein:

said sense circuit compares either said coarse reference signal or said fine reference signal to data for said non-volatile storage element to determine if said non-volatile storage element has reached a particular verification level.

11.   An apparatus according to claim 10, wherein:

said programming mode indicator includes a storage unit, said storage unit stores data indicating whether said non-volatile storage element is in said coarse programming mode or said fine programming mode.

12.   An apparatus according to claim 11, wherein:

said non-volatile storage element is a multi-state flash memory device;

said switchable charge packet metering circuit comprises a source, a first switch in communication with said source, and a capacitor;

said capacitor is in communication with said first switch and a control line for

said non-volatile storage element, said first switch selectively allows said source to charge said capacitor; and

said capacitor discharges via a control line for said non-volatile storage element in order to program said non-volatile storage element.

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13. An apparatus according to claim 1, wherein:

said non-volatile storage element is a flash memory device.

14. An apparatus according to claim 1, wherein:

10 said non-volatile storage element is a multi-state flash memory device.

15. An apparatus for programming, comprising:

a set of non-volatile storage elements having control terminals; and

an individually switchable charge packet metering system in communication with

15 said control terminals, said individually switchable charge packet metering system is individually switched to provide a particular metered charge to program non-volatile storage elements in a fine programming mode without providing said particular metered charge to program non-volatile storage elements in a coarse programming mode

20 16. An apparatus according to claim 15, wherein:

said switchable charge packet metering system comprises a charge packet metering circuit for each bit line of a set of bit lines for said set of non-volatile storage elements, each charge packet metering circuit can be separately switched.

25 17. An apparatus according to claim 15, wherein:

said switchable charge packet metering system comprises a source, a first switch in communication with said source and a first charge storage device, said first charge

storage device is in communication with said first switch and a first control line for a first non-volatile storage element, said first switch selectively allows said source to charge said first charge storage device.

5   18.   An apparatus according to claim 17, wherein:
said switchable charge packet metering system further comprises a second switch;
said second switch is in communication with said control line and said charge storage device; and
said second switch selectively connects said charge storage device to said control
10   line when said non-volatile storage element is in said fine programming mode.

       19.   An apparatus according to claim 15, wherein said switchable charge packet metering system comprises:
a first source;
15   a first switch in communication with said first source;
a first charge storage device in communication with said first switch, said first switch selectively allows said first source to charge said first charge storage device;
a second source;
a second switch in communication with said second source;
20   a second charge storage device in communication with said second switch, said second switch selectively allows said second source to charge said second charge storage device; and
a third switch for selectively connecting either said first charge storage device or said second charge storage device to a control line for a particular non-volatile storage
25   element based on whether said particular non-volatile storage element is in said coarse programming mode or said fine programming mode.

20.   An apparatus according to claim 15, wherein said switchable charge packet metering system comprises:

a variable source;

a first switch in communication with said variable source; and

5   a first charge storage device in communication with said first switch, said first switch allows said variable source to charge said first charge storage device, said first charge storage device able to provide charge to a first non-volatile storage element, said variable source charges said first charge storage device to a first level if said first non-volatile storage element is in said coarse programming mode and charges said charge first

10   storage device to a second level if said first non-volatile storage element is in said fine programming mode.

21.   An apparatus according to claim 15, wherein said switchable charge packet metering system comprises:

15   a source;

a first switch in communication with a first non-volatile storage element;

a first charge storage device in communication with said first switch; and

a second charge storage device in communication with said first switch, said first switch selectively allows said source to charge either said first storage device or said

20   second charge storage device based on whether said first non-volatile storage element is in said coarse programming mode or in said fine programming mode.

22.   An apparatus according to claim 15, wherein:

said switchable charge packet metering circuit comprises a source, a first switch

25   in communication with said source, and a capacitor;

said capacitor is in communication with said first switch and a control line for said non-volatile storage element, said first switch selectively allows said source to

charge said capacitor; and

said capacitor discharges via a control line for said non-volatile storage element in order to program said non-volatile storage element.

23. An apparatus according to claim 15, wherein:

said non-volatile storage elements include an array of flash memory devices.

24. An apparatus according to claim 15, wherein:

said non-volatile storage elements include multi-state flash memory devices.

25. An apparatus according to claim 15, wherein:

said charge packet metering system includes a charge packet metering circuit for each non-volatile storage element.

26. An apparatus for programming, comprising:

means for performing coarse programming on a non-volatile storage element;

means for determining that a threshold voltage of said non-volatile storage element has reached a first verify level and that said non-volatile storage element should be subjected to fine programming ; and

means for metering charge in said non-volatile storage element to cause said non-volatile storage element to undergo said fine programming.

27. A method for programming, comprising:

performing a coarse programming phase for a non-volatile storage element until said non-volatile storage element reaches a first condition; and

performing a fine programming phase for said non-volatile storage element by metering charge to said non-volatile storage element.

28. A method according to claim 27, wherein:

said fine programming phase is commenced for said non-volatile storage element subsequent to said coarse programming phase being completed for said non-volatile

5 storage element.

29. A method according to claim 27, wherein said metering charge to said non-volatile storage element comprises:

charging a charge storage element;

10 applying a program signal to said non-volatile storage element; and

discharging said charge storage element through said non-volatile storage element.

30. A method according to claim 29, wherein said metering charge to said

15 non-volatile storage element comprises:

connecting a capacitor to a power supply and charging said capacitor;

disconnecting said power supply from said capacitor after charging said capacitor;

applying a program signal to said non-volatile storage element; and

discharging said charge storage element through said non-volatile storage

20 element.

31. A method according to claim 29, wherein said metering charge to said non-volatile storage element comprises:

pre-charging a bit line associated with said non-volatile storage element;

25 causing said bit lines to be in a floating state after said pre-charging;

applying a common program signal to said non-volatile storage element; and

discharging said charge storage element through said non-volatile storage

element.

32.   A method according to claim 27, wherein said metering charge to said non-volatile storage element comprises:

5   switching capacitors in a charge metering system.

33.   A method according to claim 27, wherein said metering charge to said non-volatile storage element comprises:

switching power supplies in a charge metering system.

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34.   A method according to claim 27, wherein said metering charge to said non-volatile storage element comprises:

switching a variable power supply in a charge metering system.

15   35.   A method according to claim 27, wherein:

said coarse programming mode does not include metering charge to said non-volatile storage element.

36.   A method according to claim 27, wherein:

20   said a non-volatile storage element is a multi-state flash memory device.

37.   A method according to claim 27, wherein said metering charge to said non-volatile storage element comprises:

charging a charge storage element;

25   applying a common program signal to said non-volatile storage element, said common program signal is applied to multiple non-volatile storage elements along a common word line; and

discharging said charge storage element through said non-volatile storage element.

38. A method for programming, comprising:

5   performing a coarse programming process on a non-volatile storage element;

determining that said non-volatile storage element should switch to a fine programming process; and

performing said fine programming process in response to determining that said non-volatile storage element should switch to said fine programming process, said fine

10   programming process comprises:

             pre-charging a control line for said non-volatile storage element, and

             discharging said control line via said non-volatile storage element in order

to program said non-volatile storage element.

15   39. A method according to claim 38, wherein:

said step of pre-charging a control line includes charging a capacitor.

40. A method according to claim 38, wherein:

said step of pre-charging a control line includes connecting a charge storage

20   device to a power supply, said charge storage device is connected to said non-volatile

storage element; and

          said step of discharging said control line includes disconnecting said power

supply from said charge storage device.

25   41. A method according to claim 38, wherein:

said control line is a bit line for multiple non-volatile storage elements.

42.   A method according to claim 38, wherein:

said control line is pre-charged using a variable power supply; and

said fine programming process comprises changing said variable power supply to provide a signal appropriate for said fine programming process.

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43.   A method according to claim 38, wherein:

said control line is pre-charged during said coarse programming process using a first power supply;

said control line is pre-charged during said fine programming process using a

10   second power supply; and

said fine programming process includes switching from said first power supply to said second power supply.

44.   A method according to claim 38, wherein:

15   said control line is pre-charged during said fine programming process using a first charge storage device;

said control line is pre-charged when not in said fine programming process using a second charge storage device; and

said fine programming process includes switching from said second charge

20   storage device to said first charge storage device.

45.   A method according to claim 38, wherein:

said non-volatile storage element is a multi-state flash memory device.

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